

XLIX.—On the Geological Distribution of the *Rhabdophora*.
By CHARLES LAPWORTH, F.G.S. &c.

Part II. DATA.

[Continued from p. 341.]

Bala Formation.

In the present state of our knowledge it is impossible to fix upon the physical or palæontological line of demarcation between the Llandeilo and Bala (or Caradoc) formations. The Upper Llandeilo and Lower Bala rocks both consist, in great part, of dark and more or less carbonaceous shales, tolerably prolific in Graptolites. In the south of Scotland, strata of this nature (*the Glenkiln Shales*), unequivocally superior in systematic position to the generality of the Welsh Llandeilo rocks, afford a Graptolite fauna of a most distinctive character, but which, upon the whole, has a facies intermediate between that of the typical Llandeilo of Siluria and that discoverable in strata of undoubted Bala age. I have hitherto looked upon this Glenkiln fauna as of Upper Llandeilo age. Not only, however, have I failed this summer in detecting many of its most characteristic species in the highest Llandeilo rocks of South Wales, but the recent researches of American geologists appear almost to demonstrate that in New York and Canada a similar fauna is characteristic of the shaly strata immediately overlying the Trenton Limestone—in other words, of shales admittedly homotaxeous with the lower beds of the British Bala formation. This also appears to be the systematic place of the same fauna in Ireland and in Scandinavia. Till the lowest boundary of the Bala has been satisfactorily settled by careful research in the typical districts of North Wales, it is perhaps a matter of no great moment whether the fauna in question be considered as of Upper Llandeilo or of Lower Bala age. At present, however, the balance of evidence leans decidedly in the latter direction. It will therefore be more convenient to regard this peculiar fauna, provisionally, as of Lower Bala age.

Llandeilo-Bala or Lower Bala.

Scotland.—The Glenkiln or Lower Moffat shales of the south of Scotland, above referred to, yield, both in the typical localities near Moffat and in the district of the Leadhills, the following species:—

Didymograptus superstes, Lapw.
Cænograptus gracilis, Hall.

Cænograptus surcularis, Hall.
— *explanatus*, Lapw.

Cœnograptus pertenuis, <i>Lapw.</i>	Lasiograptus? bimucronatus, <i>Nich.</i>
Leptograptus flaccidus, <i>Hall.</i>	Diplograptus foliaceus, <i>Murch.</i>
Dicellograptus divaricatus?, <i>Hall.</i>	— dentatus, <i>Brongn.</i>
— patulosus, <i>Lapw.</i>	— angustifolius, <i>Hall.</i>
— sextans, <i>Hall.</i>	— tricornis, <i>Carr.</i>
Dicranograptus formosus, <i>Hopk.</i>	— Whitfieldi, <i>Hall.</i>
— ziczac, <i>Lapw.</i>	— euglyphus, <i>Lapw.</i>
— Nicholsoni, <i>Hopk.</i>	Climacograptus bicornis, <i>Hall.</i>
— ramosus, <i>Hall.</i>	— Scharenbergi, <i>Lapw.</i>
Clathrograptus cuneiformis, <i>Lapw.</i>	— perexcavatus, <i>Lapw.</i>
Glossograptus Hincksii, <i>Hopk.</i>	— ? cœlatus?, <i>Lapw.</i>
Lasiograptus Harknessi, <i>Nich.</i>	

The lowest or *Stinchar Division* of the Lower Palæozoic rocks of Girvan includes the two conglomerates of the valley of the Stinchar, with an intermediate limestone (Craighead) and some overlying shales. The Crustacea and Brachiopoda are of a Lower Bala type with numerous Llandeilo (Trenton) affinities. The Graptolites I have collected from this division include, among others, the following Glenkiln forms:—

Dicranograptus formosus, <i>Hopk.</i>	Climacograptus bicornis, <i>Hall.</i>
— ramosus, <i>Hall.</i>	— cœlatus, <i>Lapw.</i>
Glossograptus Hincksii, <i>Hopk.</i>	Diplograptus tricornis, <i>Carr.</i>
Lasiograptus Harknessi, <i>Nich.</i>	— dentatus, <i>Brongn.</i>
Dicellograptus moffattensis?, <i>Carr.</i>	— foliaceus, <i>Murch.</i>
Leptograptus flaccidus, <i>Hall.</i>	— angustifolius, <i>Hall.</i>
Climacograptus Scharenbergi,	— euglyphus, <i>Lapw.</i>
<i>Lapw.</i>	

Ireland.—Every form of Graptolite enumerated in the Glenkiln list given above has been detected in similar association in corresponding rocks (Ballygrot beds) in the Lower Palæozoic strata of county Down by my friend Mr. William Swanston, F.G.S., at Ballygrot and other localities to the south of Belfast Lough*.

Portions of the same fauna have also been recognized at several localities in the south of Ireland. In Tramore Bay, county Waterford, the following forms were collected by officers of the Geological Survey, from dark shales interbedded with fossiliferous rocks full of Lower Bala fossils †.

Didymograptus, sp. (<i>Hisingeri</i> , <i>Baily</i>).	Diplograptus foliaceus, <i>Murch.</i>
Dicellograptus sextans, <i>Hall.</i>	Climacograptus bicornis, <i>Hall.</i>
Cœnograptus gracilis, <i>Hall.</i>	Dicranograptus ramosus, <i>Hall.</i>

In the neighbourhood occur *Leptograptus flaccidus*, *Hall.*, and a species of *Didymograptus* (*Hisingeri*).

* Swanston, Trans. Belfast Naturalists' Field-Club, Appendix, 1876-1877.

† Memoirs Geol. Surv. Ireland, Explanation Sheet 167, &c., p. 23, *et seq.*; also Baily, Quart. Journ. Geol. Soc. 1869, vol. xxv. pp. 158-162.

At Ballemoney near Gorey, in the adjacent county of Wexford, a similar group of forms is met with, viz. :—

Didymograptus (Hisingeri).	Diplograptus mucronatus, <i>Hall</i> .
Dicellograptus sextans, <i>Hall</i> .	Climacograptus (bicornis ?), <i>Hall</i> .
Leptograptus flaccidus ?, <i>Hall</i> .	Dicranograptus ramosus, <i>Hall</i> .

The most prolific locality, however, appears to be that of Six-Mile Bridge, county Clare, on the western slope of the Slieve Bernagh mountains. From this locality Mr. Baily quotes

Cœnograptus gracilis, <i>Hall</i> .	Diplograptus Baylii, <i>Carr</i> .
Dicellograptus sextans, <i>Hall</i> .	— foliaceus, <i>Murch</i> .
Climacograptus bicornis, <i>Hall</i> .	Didymograptus, sp. (Hisingeri).

and some others.

Wales.—The Graptolitic black mudstones of Llanfaelrhys, Anglesey, noticed by Mr. Salter, probably belong also to this doubtful horizon. They occur in the neighbourhood of limestones of Bala age, and yield *Dicranograptus formosus**, Hopk., *Climacograptus Scharenbergi*, Lapw., and species of *Didymograptus*.

America.—The typical Glenkiln fauna of South Scotland reappears almost unmodified in corresponding strata on the continent of North America. It is confined to the convoluted shales that form the banks of the Hudson River in the neighbourhood of Albany, and to their Canadian equivalents. These so-called Hudson-River shales were formerly regarded by the great majority of American palæontologists as the representatives of the Lorraine shales that form the highest member of the Ordovician of Western New York. I have myself advocated the theory that they are of much earlier date, and inferior in systematic position to the Trenton Limestone. In the face of recent discoveries, however, neither of these theories appears to be any longer tenable. Mr. Whitfield's opinion, that they correspond, generally speaking, to the Utica Slates of Western New York and Canada, is probably the nearest to the truth; but it is possible that some of the fossils quoted from them belong in time to the upper beds of the Trenton Limestone of the west.

At the locality of Norman's Kiln, near Albany, Professor Hall has collected

Clematograptus multifasciatus, <i>Hall</i> .	Cœnograptus gracilis, <i>Hall</i> .
Didymograptus serratulus, <i>Hall</i> .	— surcularis, <i>Hall</i> .
— superstes ?, <i>Lapw</i> .	Dicranograptus ramosus, <i>Hall</i> .
	— furcatus, <i>Hall</i> .

* Salter, Mem. Geol. Survey, vol. iii. p. 256; Quart. Journ. Geol. Soc. vol. viii. p. 359.

Dicellograptus sextans, <i>Hall.</i>	Diplograptus foliaceus, <i>Murch.</i>
— divaricatus, <i>Hall.</i>	— mucronatus, <i>Hall.</i>
Clathrograptus Geinitzianus, <i>Hall.</i>	— angustifolius, <i>Hall.</i>
Diplograptus marcidus, <i>Hall.</i>	Glossograptus spinulosus, <i>Hall.</i>
— Whitfieldi, <i>Hall.</i>	Climacograptus bicornis, <i>Hall.</i>

Of these species the following occur in similar beds in the valley of the St. Lawrence, Canada* :—

Diplograptus foliaceus, <i>Murch.</i>	Dicellograptus sextans, <i>Hall.</i>
Climacograptus bicornis, <i>Hall.</i>	— divaricatus, <i>Hall.</i>
Dicranograptus ramosus, <i>Hall.</i>	Cœnograptus gracilis [?] , <i>Hall.</i>

From the enigmatical Taconic shales of the valley of the Hudson, Dr. Emmons collected a few of the same forms†, viz. :—

Cœnograptus gracilis, <i>Hall.</i>	Didymograptus, sp.
Glossograptus ciliatus, <i>Emm.</i>	

and from shales in Augusta County, Virginia, possibly of the same geological age, *Dicranograptus ramosus*, Hall, and several other species of Graptolites of the Norman's-Kiln type. A few like forms are also quoted by him from the shales of Parrottsville, Tennessee, which are apparently upon a similar geological horizon.

The only Graptolite hitherto quoted from the true Trenton Limestone is *Diplograptus amplexicaule*, Hall‡. The overlying Utica Slate affords at Oxtungo Creek, Fort Plain, New York, the following species§ :—

Didymograptus serratulus [?] , <i>Hall.</i>	Climacograptus bicornis, <i>Hall.</i>
Diplograptus foliaceus, <i>Murch.</i>	Dicranograptus ramosus, <i>Hall.</i>

From strata overlying the Trenton Limestone of Nevada, Dr. Charles White enumerates ||

Dicranograptus ramosus, <i>Hall.</i>	Diplograptus quadrimucronatus,
Diplograptus hypniformis, <i>White.</i>	<i>Hall.</i>
	— foliaceus, <i>Murch.</i>

Australia.—A few forms of this Llandeilo-Bala fauna are enumerated by Professor M'Coy from the so-called Llandeilo Flags of Australia. The forms that may possibly belong to this general horizon are ¶

* Hall, 20th Report State Cabinet, New York, p. 221.

† Emmons, 'American Geology,' vol. i. pp. 104, 110.

‡ Hall, Pal. New York, vol. i. p. 79.

§ Whitfield, Report 100th Meridian, vol. iv. p. 10.

|| Dr. C. White, Report West 100th Meridian, vol. ii. Palæontology, p. 9.

¶ M'Coy, 'Prodromus Palæontology of Victoria,' decade ii. pl. xx. &c.

Didymograptus extensus?, <i>Hall.</i> †	Cœnograptus gracilis, <i>Hall.</i>
Dicranograptus ramosus, <i>Hall.</i>	Goniograptus Thueauri, <i>M' Coy.</i>
— furcatus, <i>Hall.</i>	

Higher Bala or Caradoc Formation.

Wales.—We now ascend into the rocks of which the Bala or Caradoc age is unequivocal. The most prolific graptolite-bearing rocks of this date known to myself in Wales are exposed in the railway-cutting a little west of the town of Conway. Here the black shales of the district are crowded with poorly preserved forms, principally*

Dicranograptus Clingani, <i>Carr.</i>	Diplograptus foliaceus, <i>Murch.</i>
Idiograptus margaritatus, <i>Lapw.</i>	Climacograptus bicornis, <i>Hall.</i>

In the railway-cutting near the tunnel above Cynghordy station, South Wales, the black shales of Bala age have afforded me

Diplograptus foliaceus, <i>Murch.</i>	Dicellograptus Forchhammeri, <i>Gein.</i>
Climacograptus bicornis, <i>Hall.</i>	

and a few others.

In the Harnage shales of the Caradoc area of Shropshire, *Diplograptus foliaceus* is not uncommon. A species of *Climacograptus*, allied to *C. Wilsoni*, *Lapw.*, was met with by myself at Soudley. An example of *D. foliaceus*, *Murch.*, from the Caradoc of Robeston Wathen, is preserved in the Jermyn-Street Museum †.

Scotland.—The higher Caradoc beds of Wales are represented in South Scotland by the Middle Moffat beds, or *Hartfell Shales*. Up to the present date I have collected from these the following species:—

Pleurograptus linearis, <i>Carr.</i>	Glossograptus Hincksii, <i>Hopk.</i>
— radiatus, <i>Lapw.</i>	Lasiograptus Harknessi, <i>Nich.</i>
Amphigraptus divergens, <i>Hall.</i>	Idiograptus margaritatus, <i>Lapw.</i>
Leptograptus flaccidus, <i>Hall.</i>	Retiolites fibratus, <i>Lapw.</i>
— capillaris, <i>Carr.</i>	Climacograptus bicornis, <i>Hall.</i>
Dicellograptus moffatensis, <i>Carr.</i>	— caudatus, <i>Lapw.</i>
— anceps, <i>Nich.</i>	— tubuliferus, <i>Lapw.</i>
— Forchhammeri, <i>Gein.</i>	— Wilsoni, <i>Lapw.</i>
— Morrisi, <i>Hopk.</i>	— Scharenbergi, <i>Lapw.</i>
— caduceus, <i>Lapw.</i>	Diplograptus foliaceus, <i>Murch.</i>
— elegans, <i>Carr.</i>	— tricornis, <i>Carr.</i>
— complanatus, <i>Lapw.</i>	— truncatus, <i>Lapw.</i>
Dicranograptus ramosus, <i>Hall.</i>	— quadrimucronatus, <i>Hall.</i>
— Nicholsoni, <i>Hopk.</i>	— socialis, <i>Lapw.</i>
— Clingani, <i>Carr.</i>	— euglyphus, <i>Lapw.</i>

* Compare also Salter, *Memoirs Geol. Surv.* vol. iii. pl. xii. &c.

† Case iv. | 25.

The second or Ardmillan Division of the Girvan rocks is composed of the four successive subgroups of the Pinmore, Tralodden, Shalloch, and Drummuck beds. The Pinmore beds have yielded me

Dicranograptus ramosus, Hall.
Dicellograptus moffatensis, Carr.
Leptograptus flaccidus, Hall.
Diplograptus foliaceus, Murch.
 — *euglyphus*, Lapw.

Diplograptus tricornis, Carr.
Climacograptus Scharenbergi,
 Lapw.
 — *cælatus*, Lapw.

The Tralodden beds afford

Dicellograptus elegans, Carr.
 — *Forchhammeri*, Geinitz.
 — *Morrisi*, Hopk.
 — *complanatus*, Lapw.
Diplograptus foliaceus, Murch.
 — *socialis*, Lapw.

Diplograptus truncatus, Lapw.
 — *quadrimucronatus*, Hall.
Climacograptus bicornis, Hall.
 — *tubuliferus*, Lapw.
Idiograptus aculeatus, Lapw.

The Shalloch or Nematolites-beds yield only a few specimens of

Dicellograptus Morrisi, Hopk.
Diplograptus foliaceus, Murch.

Diplograptus truncatus, Lapw.
Idiograptus margaritatus, Lapw.

The Drummuck beds are also very poor in Graptolites. The only forms hitherto collected from them by Mrs. Gray or myself include

Dicellograptus anceps?, Nich.

Diplograptus truncatus, Lapw.

Ireland.—The central member of the Black Graptolitic shales of county Down has yielded to the industrious researches of my friend Mr. William Swanston the following Hartfell species:—

Leptograptus flaccidus, Hall.
Dicellograptus caduceus, Lapw.
 — *moffatensis*, Carr.
 — *Forchhammeri*, Geinitz.
 — *Morrisi*, Hopk.
Dicranograptus ramosus, Hall.
 — *Clingani*, Carr.
 — *Nicholsoni*, Hopk.

Climacograptus bicornis, Hall.
 — *Scharenbergi*, Lapw.
 — *tubuliferus*, Lapw.
Retiolites fibratus, Lapw.
Diplograptus truncatus, Lapw.
 — *foliaceus*, Murch.
 — *quadrimucronatus*, Hall.
 — *tricornis*, Carr.

Sweden.—The Swedish Graptolite-bearing rocks that correspond to the Llandeilo and Bala strata of Britain are the *Middle Graptolite-Schists* of Linnarsson (*Dicranograptus-Schists* of Dr. Tornquist) and the overlying *Trinucleus-Schist*. These beds repose at once upon the *Orthoceras-Limestone* (Arenig), and are surmounted by the *Brachiopod-Schists* (Llandovery) that form the basal formation of the Swedish Silurian proper. According to the most recent communica-

tions of Mr. Linnarsson, the *Middle Graptolite-Schists* of Scania are composed of the following subgroups of strata in ascending order* :—

(a) Zone with *Phyllograptus typus* (Hall ?),

containing, in addition to *Phyllograptus typus*, representatives of the under-named British species :—

<i>Didymograptus patulus</i> , Hall.	<i>Climacograptus confertus</i> , Lapw.
— <i>geminus</i> , His.	— <i>perexcavatus</i> , Lapw.
<i>Diplograptus Hopkinsoni</i> , Nich.	— <i>Scharenbergi</i> , Lapw.

(b) Zone with *Didymograptus geminus* (*Didymograptus Murchisoni* of British Palæontologists).

This is characterized, like the corresponding British zone, by the abundance of the tuningfork-shaped *Didymograpti* generally known under the names given above. They occur together with many of the same forms common in the underlying zone (with the notable exception of *Phyllograptus*) and the addition of *Diplograptus foliaceus*, Murch.

(c) Zone with *Glossograptus Hincksi*, Hopk.

The chief fossil of this zone is a beautiful form of *Glossograptus* doubtfully referable to Hopkinson's species. The *Murchisoniform* *Didymograpti* are wanting; and only a single patulous species remains. *Dicellograptus* (*Dicellograptus moffatensis* ?, Carr.) makes its first appearance in this zone.

(d) Zone with *Diplograptus mucronatus* (Linnrs.).

The characteristic fossil of this zone is a peculiar Graptolite, probably an *Idiograptus*. The associated forms are identical with, or allied to, the British species :—

<i>Diplograptus foliaceus</i> , Murch.	<i>Climacograptus caudatus</i> , Lapw.
— <i>tricornis</i> , Carr.	<i>Dicellograptus sextans</i> , Hall.
— <i>teretiusculus</i> , His.	— <i>moffatensis</i> , Carr.

(e) Zone with *Climacograptus Scharenbergi*, Lapw.

This is marked by the prevalence of the species to which the zone owes its name, and rarer examples of the representatives of

<i>Diplograptus foliaceus</i> , Murch.	<i>Diplograptus teretiusculus</i> , His.
— <i>Hopkinsoni</i> ?, Nich.	<i>Didymograptus superstes</i> , Lapw.

* Linnarsson, Geol. Föreningens Förhandl. 1879, Bd. iv. no. 8.

(f) Zone with *Dicranograptus Clingani*, Carr.

This is locally prolific in the British forms

Diplograptus foliaceus, *Murch.*
 — *quadrimucronatus*, *Hall.*
Climacograptus bicornis, *Hall.*
 — *caudatus*, *Lapw.*

Lasiograptus, sp. n.
Dicranograptus Clingani, *Carr.*
Dicellograptus Forchhammeri, *Gein.*
 — *Morrisi*, *Hopk.*

(g) Zone of *Orthis argentea*, His.

The only species noted from this zone is an undetermined form of *Climacograptus*.

These results harmonize the data previously collected from the district by former observers*, and are in strict concordance with the little that is yet known respecting the fossils of the corresponding strata in Westrogothia, Dalarne, and the island of Bornholm †.

The zones (a) and (b) represent those British strata which, pending the advent of a more suitable title, we may term the Passage-beds between the Arenig and Llandeilo formations. The zone (a) is essentially Arenig in its general facies. The zone (b) is the exact representative of the Lower Llandeilo or *Murchisoni*-zone of Aberciddy Bay. The zones (c) and (d) are, as Linnarsson remarks, distinctly of Llandeilo age. Zone (e) is probably the equivalent of the transitional Glenkiln shales of South Scotland. Zones (f) and (g) are, as Linnarsson observes, the Swedish representatives of the main mass of the Hartfell shales, and are therefore of unequivocal Bala age.

The highest strata of the Swedish Ordovician are the so-called *Trinucleus-Schists*. The only Graptolites they have yielded hitherto are ‡

Diplograptus pristis, *His.*

Dicellograptus elegans, *Carr.*

America.—The Hudson-River group or *Lorraine Shales* of New York and Canada, and their western representative the *Cincinnati group* of Ohio, occupy the systematic place of the British Caradoc rocks. Only a few Graptolites are yet known from these beds. From the Cincinnati group Hall enumerates §

Climacograptus bicornis, *Hall.*
 — *typicalis*, *Hall.*

Diplograptus putillus, *Hall.*

* Tornquist, Öfvers. af K. Vet. Akad. Förh. 1875, no. 10, 4; Linnarsson, Geol. Fören. no. 22, 1875, &c.

† Johnstrup, Forh. Skand. Naturf. 11 (Copenhagen, 1873), pp. 305–308.

‡ Conf. Linnarsson, Geological Magazine, June 1876.

§ Hall, Grapt. Quebec Group, p. 44, &c.

In the Utica or Hudson-River Shales of Lake St. John, Lower Canada*, occur

Leptograptus flaccidus, <i>Hall.</i>	Diplograptus quadrimucronatus, <i>Hall.</i>
Diplograptus mucronatus?, <i>Hall.</i>	Retiograptus? eucharis, <i>Hall.</i>

From the Lorraine Shales of New York Professor Hall figures

Amphigraptus divergens, <i>Hall.</i>	Diplograptus hudsonicus, <i>Nich.</i>
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and some other species †.

In the corresponding beds near Montreal occur *Climacograptus bicornis*, Hall, *Diplograptus foliaceus*, Murch., and *Dicranograptus Nicholsoni*, Hopk. ‡.

L.—Note on the so-called "Farringdon (Coral-Rag) Sponges" (Calcispongiæ, Zittel). By H. J. CARTER, F.R.S. &c.

A FEW days ago, while turning out the contents of a box, I found a parcel of fossils labelled "Coral Rag," and, on opening it, not only saw that it contained several beautiful specimens of the so-called "Farringdon sponges," but recollected that these fossils had been given to me by a dear fellow student who lived at or near Farringdon in Berkshire, and whose untimely decease, somewhere about forty years ago, was about coeval with the present; thus the parcel seems to have been unopened for this lapse of time.

At once I observed that the Farringdon sponges belonged to the Order called by Professor Zittel, in his "Studies on Fossil Sponges" §, "Calcispongiæ," which were first brought to my notice by his kindness in not only sending me entire specimens of these sponges themselves from the "Upper Jura, &c.," but slides of *Peronella multidigitata* and *P. cylindrica* respectively—showing that these, at least, contained triradiate spicules which, in the former, to me as well as to himself, seemed to be identifiable *only* with those of a recent Calcisponge.

* Hall, Grapt. Quebec Group, pp. 143 &c.

† Hall, Grapt. Quebec Group, p. 13; Palæontology New York, vol. i. pl. 72.

‡ Logan, 'Geology of Canada,' p. 200.

§ Abhandlungen der k. bayer. Akad. der Wiss. ii. Cl. Band xiii., 1877, I. Hexactinellidæ; *Ib. ib.* Abth. i. pp. 67-154, II. Lithistidæ; *Ib. ib.* pp. 93-138, III. Monactinellidæ, Tetractinellidæ, und Calcispongiæ. 'Annals,' 1877, vol. xx. p. 357 *et seq.*; 1878, vol. ii. p. 113 *et seq.*; 1879, vol. iii. p. 304, respectively. Translated by W. S. Dallas, F.L.S.